

units respectively, and without mutual action. The total energy is $m(9^2+1^2)=82m$, the total momentum due north is $2m(9+1)$, that due east is zero. At 12 o'clock the sprite wills that the first body should diminish its velocity due north to 5 and get one of 4 due east, while at the same time the second shall increase its velocity to 5 due north and get one of 4 due west. The bodies obey the sprite, of course, and even though he has by no means confined himself to "guiding or controlling forces," the energy remains the same, for $m(5^2+4^2+5^2+4^2)=82m$, and the total momentum north is $2m(5+5)$, and that east is $2m(4-4)$, i.e. $20m$ and 0, the same as before.

Now suppose a materialistic philosopher had been observing all this. Before 12 o'clock his observations of the continued uniform motion of the bodies would have led him to conclude that there was no mutual action between them, i.e. the law of the force was that it was zero. At 12 o'clock he would observe a change, and if ignorant that there was a sprite, would conclude that some other system, unseen by him, had come into collision with his system. If he is assured this is not the case, he will be driven to the only alternative, viz. that at 12 o'clock the *law of the action between them* had suddenly changed. (For the philosopher to say that a *force* had acted on the balls at 12 o'clock would be merely another way of saying that their motion had changed, because the definition of force, derived from Newton's laws, is "that which changes the state of motion of a body.") Hence, whether he thought the action was due to a sprite, to an external material system, or to a change in the law of action between the bodies, the statement that at 12 o'clock a force had acted on each would be equally appropriate; and whatever supposition be adopted, the force would have the direction and magnitude, viz. that deduced by Newton's laws from the observed changes in the motion.)

Replace the two particles by the entire universe, and the point in dispute is really this. The physicist says, the changes in the motion of each particle at any instant depend solely on the positions of it and all the other particles, *according to laws which do not change with the time*. The form of the dependence, too, shows that there is but one future course of the motion— $\kappa.\lambda.\pi.v.$'s singular solutions do not come in—and that it only needs infinite mathematical knowledge to calculate, from the positions and velocities at 12 o'clock to-day, and the unalterable laws of mutual action, what every particle of the system will be doing at, say, 3 o'clock three hundred years hence.

It is open to anyone to deny this position, but he ought, I think, to state exactly how far he does deny it, even though he may not be able to state exactly what he wishes to substitute for it. What it seems to me necessary for Sir Oliver Lodge to deny is that these laws apply to living matter. He must say that if the motions of the material particles of which protoplasm is composed be examined (in conjunction, of course, with those of the rest of the universe), our materialistic philosopher would be compelled to conclude that a change in the law of action had taken place—just as he would in the case of the two particles, if he were certified that they composed the whole universe. The materialist philosopher would then, I imagine, be prepared to receive with attention, at all events, Sir Oliver's assurance that these extraordinary changes were due to an exertion of will- or psychic-power on the part of the protoplasm, and that the law of mutual action between the material particles was not changed at all—it was only "supplemented," I suppose he would say, by the action of mind on matter.

Whether this is really so or not is perhaps open to that reasonable doubt which may exist on any matter which has not been made the subject of conclusive experiment, and any man is entitled to say that he doubts whether an observation of the motions of live matter would not reveal something incompatible with the supposition that the "forces" acting on the particles of the universe are determined according to any fixed law, i.e. a law independent of the time.

It would be interesting, but inappropriate, to discuss how far such a supposition will help people in regard to "the efficacy of prayer and many another practical outcome of religious belief," the reality of which Sir Oliver and many others consider to depend on the attitude taken in regard

to it. Practically the effect of a general adoption of the supposition would be that for many years to come it would be thought to have removed the difficulties, but after a time these would crop up exactly as before. When men became more familiar with the conception of spirit, they would ask of it also, *what laws it followed*, and in the mental, as in the physical world, the conception of a necessary law of operation would assert its absolute sway among the higher minds who make knowledge their object. For it is only that which is subject to law which can be the object of knowledge. That which is capricious can only be the subject of memory and conjecture. It is not in this direction that any permanent solution of difficulties is to be sought.

EDWARD P. CULVERWELL.

Trinity College, Dublin, May 28.

IN relation to the letters on "Psychophysical Interaction" appearing in NATURE, the initial questioning the discussion works back to is whether we are to recognise in mind the mere knower, or manipulator, as well, of animal action. In relation to such a questioning it may be of use to consider that what is inferred concerning mind as existing anywhere outside oneself is inferred by study of action displays. We possess no faculty which can directly become aware of the psychical outside oneself. It is in action we see it, if at all. The study of animal intelligence infers as to animal intelligence by seeing it in animal action. We meet with peculiar kinds of actions which seem to require intelligence for their origin; and therefore surmise as to animal intelligence. The observation holds of the human intelligences with which we come in contact. We can only get to know the mind of a man through his action that he acts intelligently; therefore he must be intelligent. A man may speak his ideas to us, and by his speaking convince us of his inlying intelligence; but in ultimate analysis talking is as much a muscular performance as walking. Or he may write his thoughts, and we by reading may see in what he has written that he has ideas; but if the mind is mere knower it cannot manipulate action to the writing down of ideas, and therefore this is effected in some other way. For all we may know to the contrary, the man vacant of mind may be more at large than we are apt to suspect, for by the mechanical hypothesis a man may talk rationally and yet not have ideas.

The mechanical hypothesis disposes of the actions of animals by the theory of their being fitted and adapted in reciprocal relation to environment by process of natural selection. Variations in action take place in species, and the species which are favoured with favourable variations in action in the long run survive. The theory explains many of the adjustments of animal action, but not all. There are instances to which the hypothesis can never extend, and they are the instances of action which are put in in circumstances where there is no scope for natural selection to work. Take, for instance, a man learning to play a cornet. The learning to play a cornet is the putting in of an action process, and as such is worthy of biologic consideration. The man learns to play the instrument by manipulating his breathing and fingering the keys. He studies the music before him, and internally, and mentally, decides upon the fingering which is appropriate. His breathing into the instrument is timed by his mental translation of signs given by the printed page. Each stage of his practising is revised by hearing. Where he plays a false note he goes back, and exercises extra attention to do better.

The entire action of players in a cricket field is action adjusted in relation to the motion of the ball. It is action determined by seeing. Deduct the seeing and it cannot be done. And cricket has not been long enough in existence for natural selection to have anything to do with it. So the editing of NATURE is an intelligent-mechanical process. Deduct the intelligence in that process, and it cannot be done. The expert conjurer, equilibrist, or trick cyclist depends upon the alertness of his sensations for the correctness of his performance.

Apparently in the whole proceeding of animal action, excepting the old established automatic, knowing, seeing, hearing, feeling, plays its part. Ants will eat sugar but not saccharin. The *taste* to them is not as sugar. So

the lion runs to his prey with his nose to the ground, and the action of the bloodhound is valuable on account of his fine scent. It seems with mind as mere knower and non-manipulator of action these performances could not be put through.

A. BOWMAN.

144 Well Street, Hackney, May 26.

Musical Sands.

MAY I record the discovery of musical sands at places along the shore between Ramsgate and Kingsgate. The sand occurs in small patches close to the chalk cliffs, the largest patch being found at Joss Gap. In composition the sand is very similar to that of Studland Bay, but the individual grains are more polished, and the proportion of denser minerals far higher. Of course, the sand can only be experimented upon when it has been uncovered by the sea for a sufficient length of time to enable it to become dry, and it gives remarkable results when tested in the ordinary way—especially when placed in a china vessel and struck with a wooden plunger.

June 8.

CECIL CARUS-WILSON.

THE STUDY OF BACTERIAL TOXINS.

THE study of the toxins produced by bacteria is one of the most important branches of bacteriological research. The solution of some of the main problems of immunity and disease depends upon the knowledge that can be gained with reference to the nature of the bacterial toxins and their mode of action upon the animal body.

The methods introduced by Pasteur, Koch, and other observers have rendered it possible to detect and to isolate the specific agents in a number of infective processes. The number of infective diseases that have been definitely associated with the action of bacteria is considerable, e.g. tuberculosis, cholera, diphtheria, typhoid fever, &c.

It was natural that the earliest attempts to prevent the invasion of the animal body by these micro-parasites should be based more or less on the principles of Jennerian vaccination. An attenuated virus, for example, was taken and used directly as a vaccine in order to produce, if possible, an active immunity to the disease in question. This system of protective inoculation was tested in a number of diseases, and notably in infective diseases of the lower animals. The anthrax vaccine employed for the protection of cattle and sheep is a typical example of such immunising methods, whilst in recent years analogous methods of protective inoculation have been extensively used in certain diseases of man.

The study of the microparasites associated with diphtheria and tetanus showed that organisms of this type possessed not merely infective but likewise marked toxic properties. It was further established that these toxic properties were the determining factors in the production of the graver symptoms in cases of diphtheria and tetanus. It therefore became apparent that in diseases of this order, the point of cardinal importance was to combat, if possible, the toxins produced in their course. The laboratory experiments made with the diphtheria and tetanus organisms demonstrated that the poisons were soluble products of the bacterial cells in question, and were excreted into the nutrient fluids in which they had been cultivated. These toxins were proved to be of a specific nature, as they reproduced the essential general symptoms of the diseases.

Diphtheria and tetanus are therefore intoxications of the body, due to the action of specific soluble poisons produced by the parasites at the seat of infection. The toxins, on being introduced into suitable animals in carefully regulated doses, produced an active immunisation of the animals characterised by the formation in their blood of anti-bodies as regards the toxins

in question—in other words, antitoxins resulted. The antitoxic serum, when added to the toxin *in vitro*, robbed the toxin of its poisonous properties, and, probably in virtue of some chemical combination between toxin and antitoxin, a neutral mixture resulted. The serum containing these specific anti-bodies, on introduction into other animals, conferred on them a passive immunity. They were protected against the action of the toxin in question, and, most important of all, the serum was efficacious in the case of an already existing intoxication—it possessed curative as well as protective properties. If a large animal, such as a horse, was actively immunised by injection of the soluble toxins, considerable quantities of these antitoxic substances were formed and accumulated in its blood and blood-serum. In this way the serum of an animal highly charged with antitoxins became a valuable and innocuous vehicle for the introduction of these preventive and curative substances into the human system. The natural defensive forces of the body were thereby reinforced, and in the right direction. This method of serum therapeutics has had brilliant results in the case of diphtheria, and has been demonstrated to be a feasible therapeutic method in the case of tetanus. These maladies belong to the group of *intoxicative* diseases. There remained, on the other hand, a large number of diseases in which a general multiplication of the microorganisms in their host appeared to be the salient feature. It has been usual to call these, in contradistinction to the former, *infective* diseases. The successful results in the case of diphtheria led to the extensive study on similar lines of infective organisms generally. A systematic search was made for soluble bacterial poisons, as their detection would be likely to lead to valuable additions to antitoxic serum therapeutics.

The researches in this direction met with unexpected difficulties and disappointments. The results obtained in the case of diphtheria and tetanus were not found to be of general application. Each organism had therefore to be taken on its own merits, and individually studied. It speedily became apparent that, as regards a considerable number of infective agents, the conditions were not the same. On cultivation in fluid media no distinct evidence of the production of soluble poisons could be obtained, or, if present, they were so in an inappreciable amount. The attempts, therefore, to produce antitoxins by the injection of such culture fluids into animals did not promise to be of much practical value. This, as a matter of fact, has proved to be the case; the various serums prepared were found to possess little or no curative value. Many infective organisms did not apparently produce their injurious effects through the agency of soluble toxins, and consequently curative methods based on the assumption resulted in failure. Research was thrown back once more upon the living infective agents, and the possibilities there might be of protecting the body directly against their invasions, or, in other words, of producing not a poison but a bacterial immunity. Bactericidal substances were found to be present in the blood of individuals who had passed through an attack of certain infective diseases, and the bactericidal action was specific as regards the infective agent in each case. For example, the blood of a patient recovering from typhoid fever is bactericidal to the typhoid organism. In the absence of soluble immunising products, there was a strong presumption that these substances were to be sought for within the bodies of the bacteria. The bacteria in that case, if injected directly into the system, would tend to produce an active immunisation of the body, and would reinforce the bactericidal properties of the tissues in specific directions. The method most generally favoured for this purpose was the in-